

# UNDER-BODY BLAST MITIGATION: STAND-ALONE SEAT SAFETY ACTIVATION SYSTEM

**Sebastian Karwaczynski**  
US Army TARDEC

**Mehmet H. Uras**  
Paradigm Research and Engineering



UNCLASSIFIED: Distribution Statement A. Approved for public release.

Report Documentation Page			Form Approved OMB No. 0704-0188		
Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.					
1. REPORT DATE <b>08 APR 2014</b>		2. REPORT TYPE <b>Briefing Charts</b>		3. DATES COVERED <b>04-01-2014 to 18-03-2014</b>	
4. TITLE AND SUBTITLE <b>UNDER-BODY BLAST MITIGATION: STAND-ALONE SEAT SAFETY ACTIVATION SYSTEM</b>				5a. CONTRACT NUMBER <b>W56hzv-13-C-0296</b>	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S) <b>Sebastian Karwaczynski; Mehmet Uras</b>				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) <b>Paradigm Research and Engineering,3077 N Foxridge Ct ,Ann Arbor,Mi,48105-9201</b>				8. PERFORMING ORGANIZATION REPORT NUMBER <b>; #24565</b>	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) <b>U.S. Army TARDEC, 6501 East Eleven Mile Rd, Warren, Mi, 48397-5000</b>				10. SPONSOR/MONITOR'S ACRONYM(S) <b>TARDEC</b>	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S) <b>#24565</b>	
12. DISTRIBUTION/AVAILABILITY STATEMENT <b>Approved for public release; distribution unlimited</b>					
13. SUPPLEMENTARY NOTES <b>Presented to SAE World Congress 2014</b>					
14. ABSTRACT <b>1. The TARDEC GSS Blast Mitigation team is responsible for System level Occupant Centric Safety system integration 2. Designed systems are to protect the Occupant in Blast, Crash, Roll Over and other Injury Causing events 3. Reducing occupant injury and decreasing the lethality associated with various threats 4. Providing a system which can reliably and accurately activate systems such as Air Bags, Pyrotechnic Restraints and other potential emergency signaling systems during events 5. Further expanding the development of System Level Occupant Protection</b>					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT <b>Public Release</b>	18. NUMBER OF PAGES <b>21</b>	19a. NAME OF RESPONSIBLE PERSON
a. REPORT <b>unclassified</b>	b. ABSTRACT <b>unclassified</b>	c. THIS PAGE <b>unclassified</b>			

# Outline

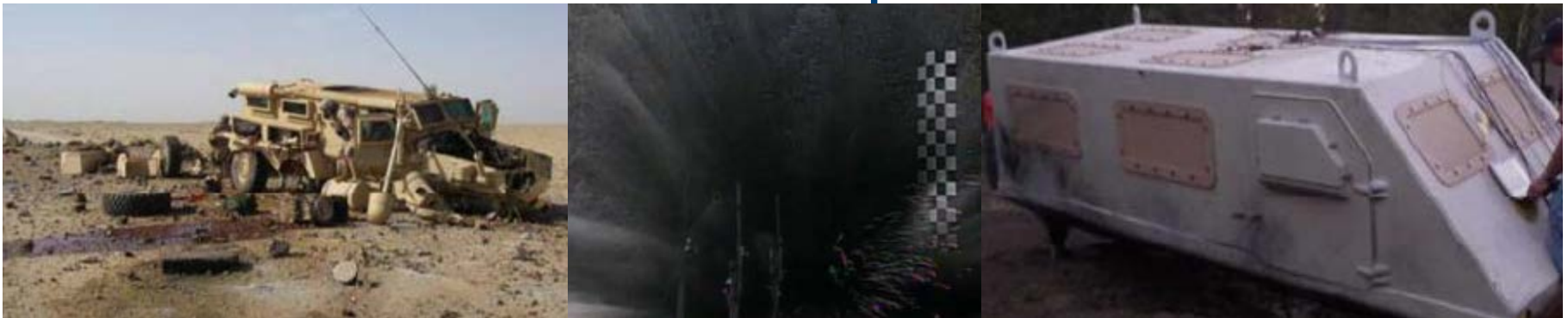
- **Mission/Military Systems and Goals**
- **Current Technology/Sensors**
- **Seat Safety Activation System Components**
- **Operating Principle of the Blast Detection Sensor**
- **Testing of the System under Impact Strains**
- **Testing of the System under Accelerations**
- **Summary of the Conclusions**

# Mission

- 1. The TARDEC GSS Blast Mitigation team is responsible for System level Occupant Centric Safety system integration**
- 2. Designed systems are to protect the Occupant in Blast, Crash, Roll Over and other Injury Causing events**
- 3. Reducing occupant injury and decreasing the lethality associated with various threats**
- 4. Providing a system which can reliably and accurately activate systems such as Air Bags, Pyrotechnic Restraints and other potential emergency signaling systems during events**
- 5. Further expanding the development of System Level Occupant Protection**

# Current Military Systems

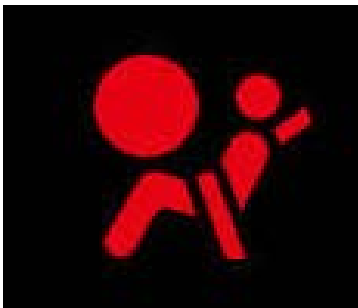
1. Current restraint systems in the Army do not utilize pyrotechnic systems
2. Sensors directly associated with Pyrotechnic systems (Military Specific) are not fielded/available
3. Integration of sensors commonly found in automotive applications would not be suitable for Military vehicles, due to the fact that peak accelerations occurring in underbody blast events are larger in magnitude and occur within a shorter time span than in an automotive crash or impact event.



# Goals

1. Create a sensor system with the capacity to activate in a Blast within 0.5 milliseconds from event initiation
2. Provide a self-contained system that is powered by an internal source and connected to indicator lights.
3. Provide diagnostic support, internal source charging and system activation
3. Create a system that couples directly to the pyrotechnic system(s)
4. Provide instantaneous system level health, I.E Malfunction Indicator Light

## *Restraint Systems Requiring a Crash/Blast Sensor*



Pyrotechnic Mechanical Retractor



Pyrotechnic Buckle



Pyrotechnic Electro-Mechanical Retractor



Inflatable Seat Belt



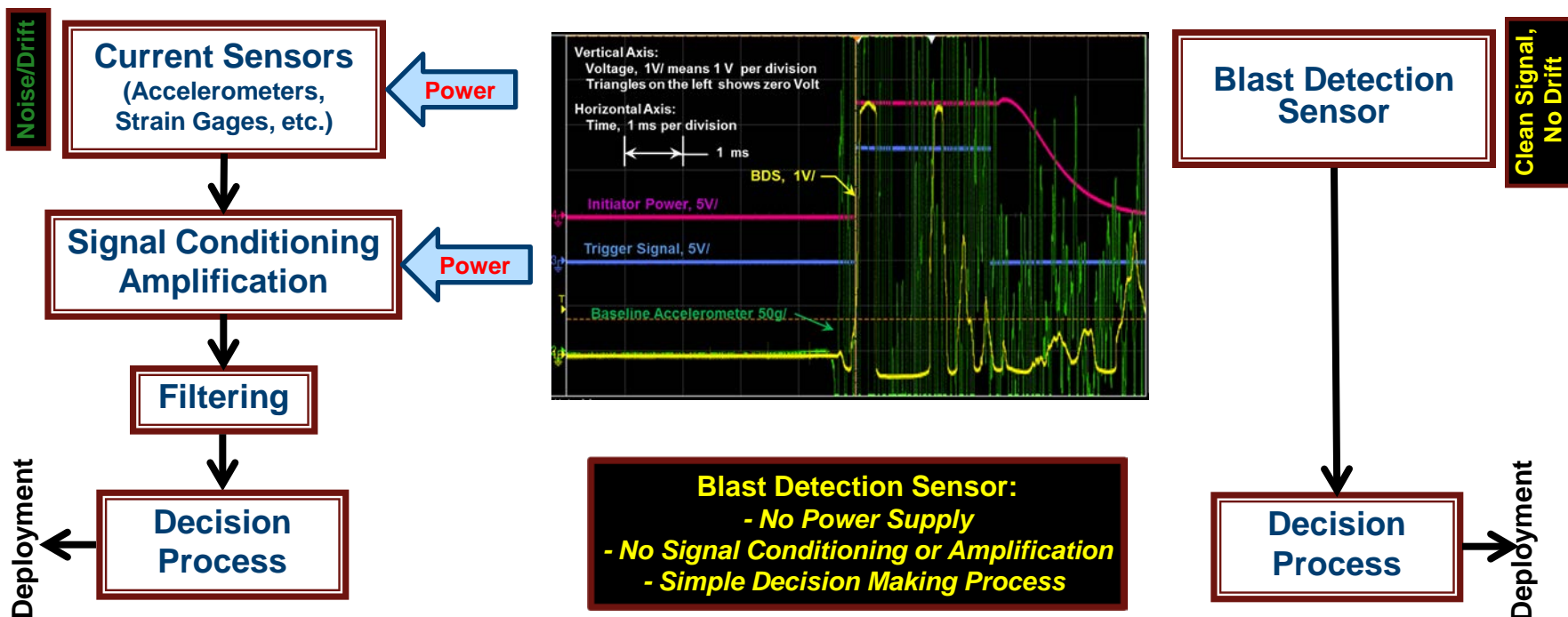
# Current Technology and Sensors

Event	Typical Peak Accelerations (g)	Typical Time Duration (ms)
Frontal Automotive Crash (30 mph)	25 to 50	70 to 120
Underbody Blast	100 to 400	3 to 30

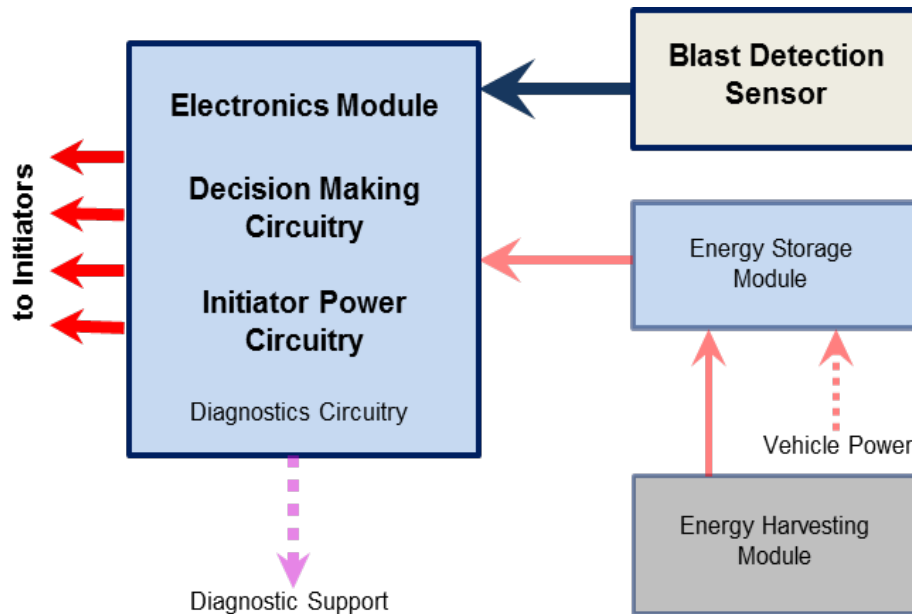
(Source: Dr. Thyagarajan, Ravi [1])

**Underbody Blast:  
Much Higher g's, Much Faster**

**Systems for Automotive Applications:  
NOT fast enough**



# Seat Safety Activation System Block Diagram



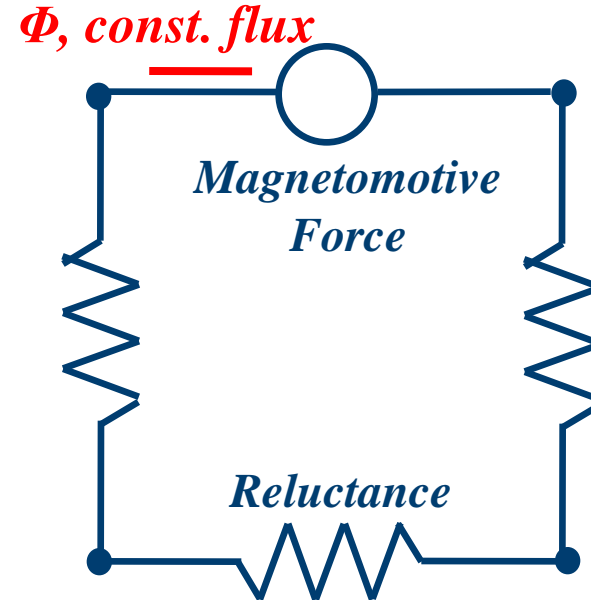
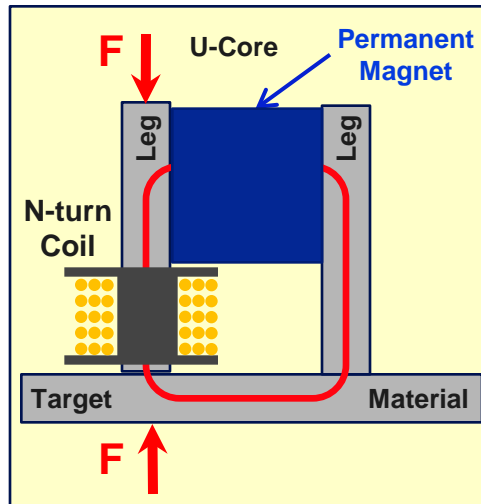
**Focus of This Paper:**  
**Blast Detection Sensor (BDS) and**  
**Decision Making Circuitry (DMC)**

# Operating Principle of Blast Detection Sensor: Constant-Flux Magnetostrictive Sensor

- **Magnetostriction:**  
*“ deformation of a magnetic material when subjected to a magnetic field ”*
- **Inverse Magnetostriction:**  
*“ change in magnetic properties when material subjected to a mechanical deformation (strain) ”*

$$\Delta \epsilon \rightarrow \Delta \mathcal{R}$$

# Operating Principle of Blast Detection Sensor: Constant-Flux Magnetostrictive Sensors



$$\Delta F \Rightarrow \Delta L \Rightarrow \Delta \epsilon \Rightarrow \Delta \mathcal{R} \quad (\text{Closed Circuit})$$

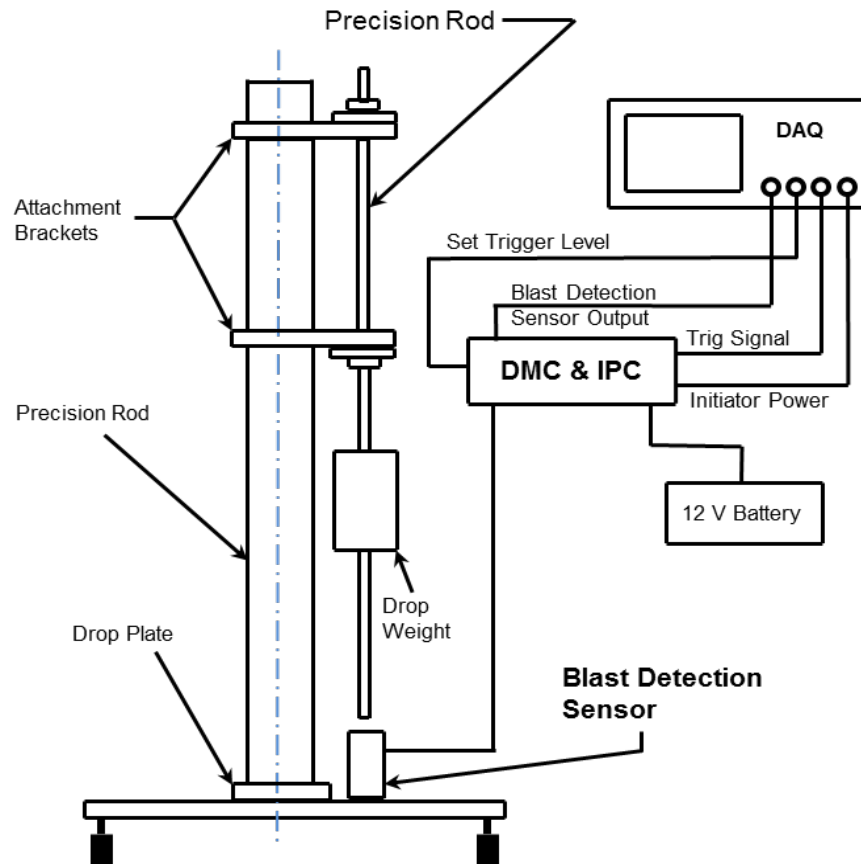
$$\Delta (\text{gap}) \Rightarrow \Delta \mathcal{R} \quad (\text{Open Circuit})$$

$$\Delta \mathcal{R} \Rightarrow \Delta \Phi$$

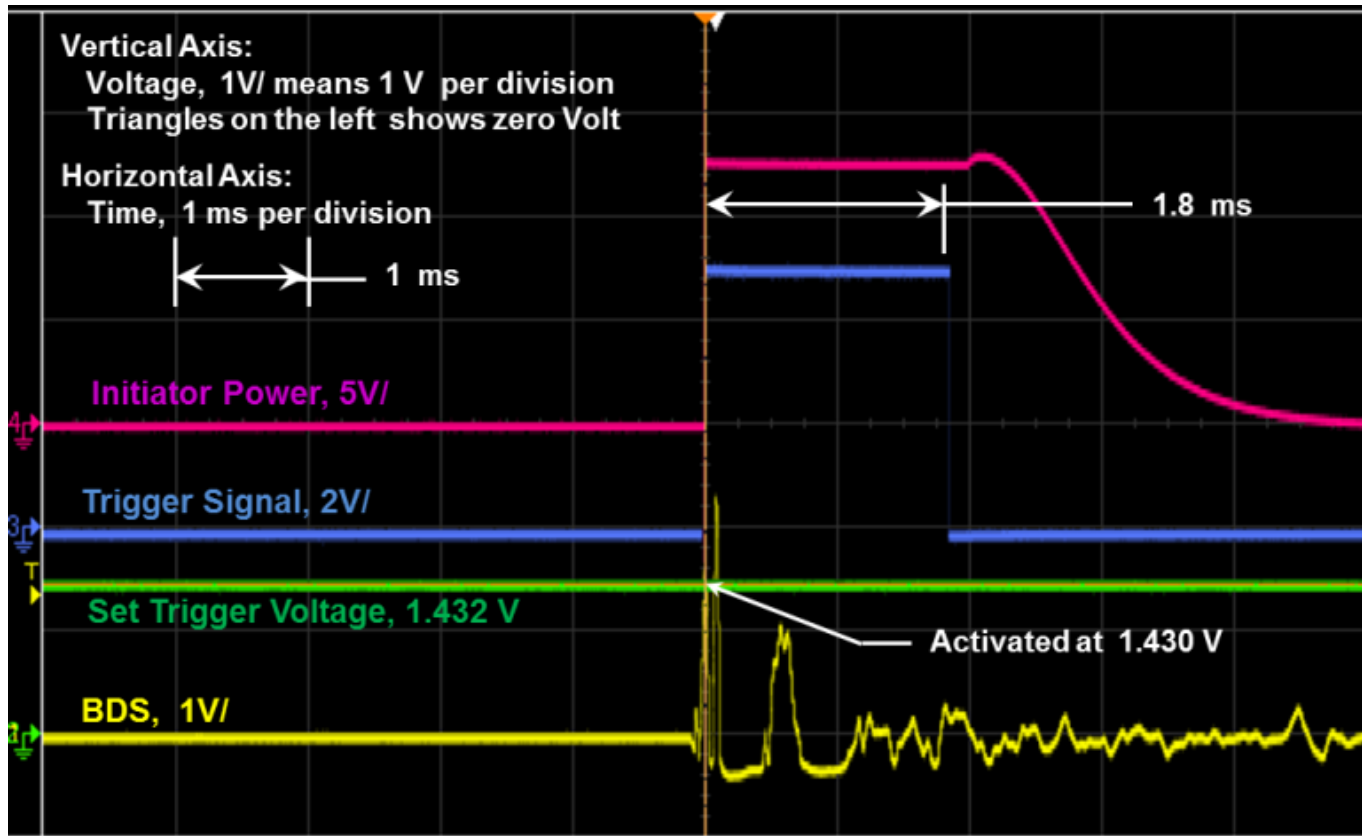
$$V = N \left| \frac{d\Phi}{dt} \right|$$

# Testing of the Activation System under Impact Strains

## Drop Tower Experimental Setup



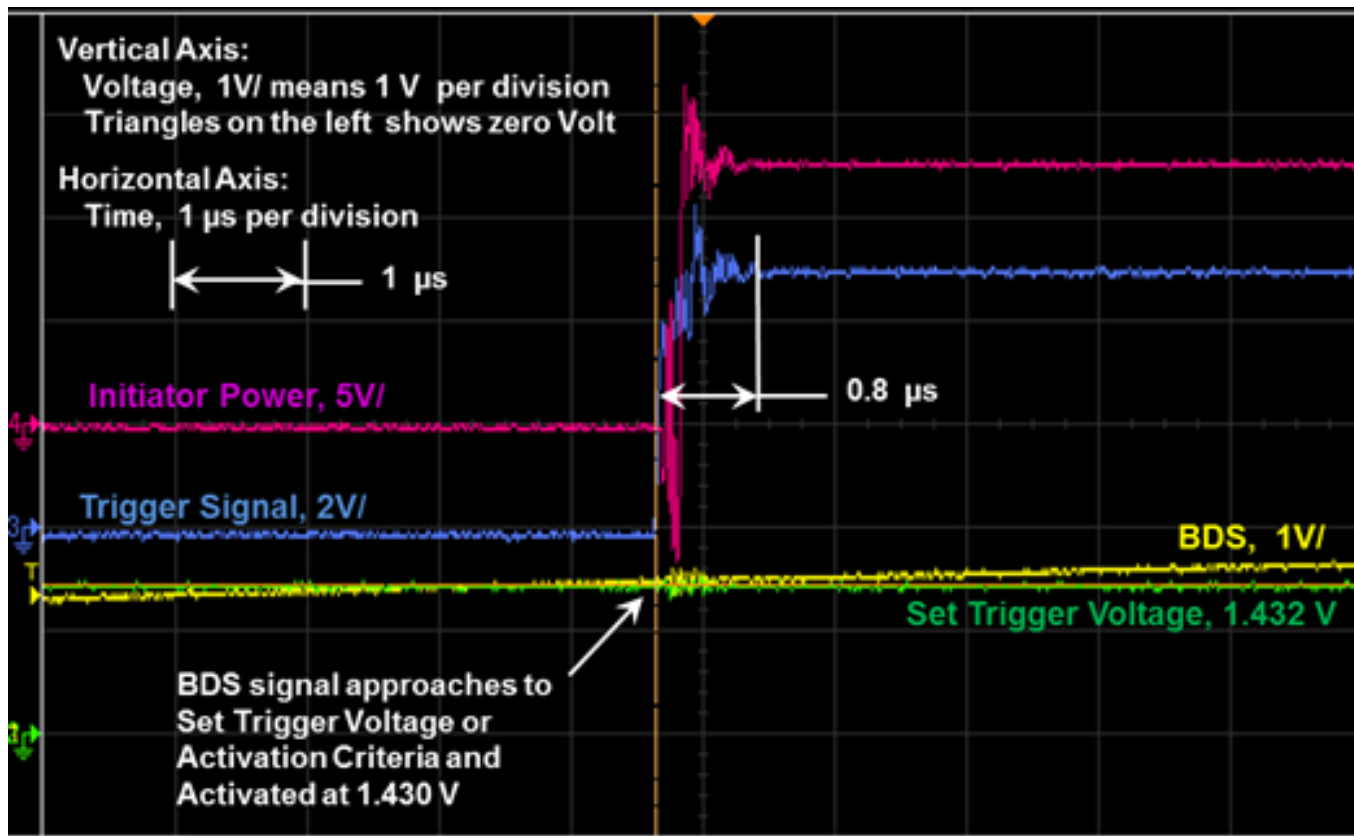
# Testing of the Activation System under Impact Strains



Sampling Rate: 100 MSa/s

# Testing of the Activation System under Impact Strains

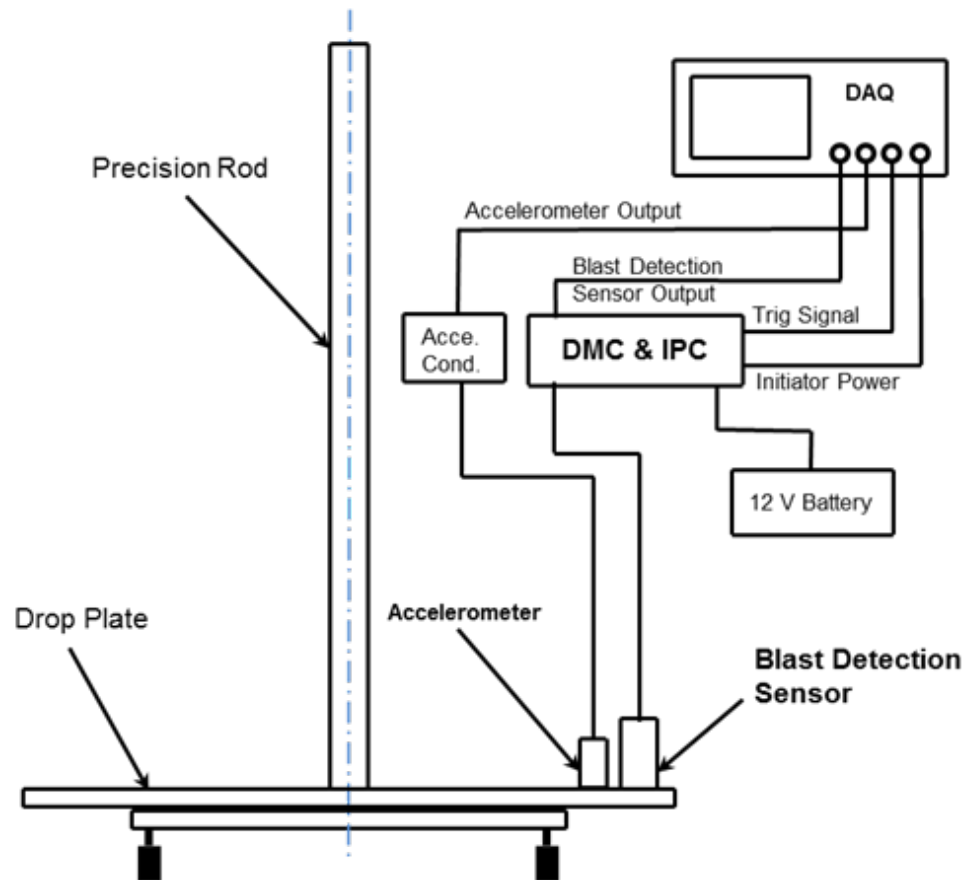
## 1000x Expanded View



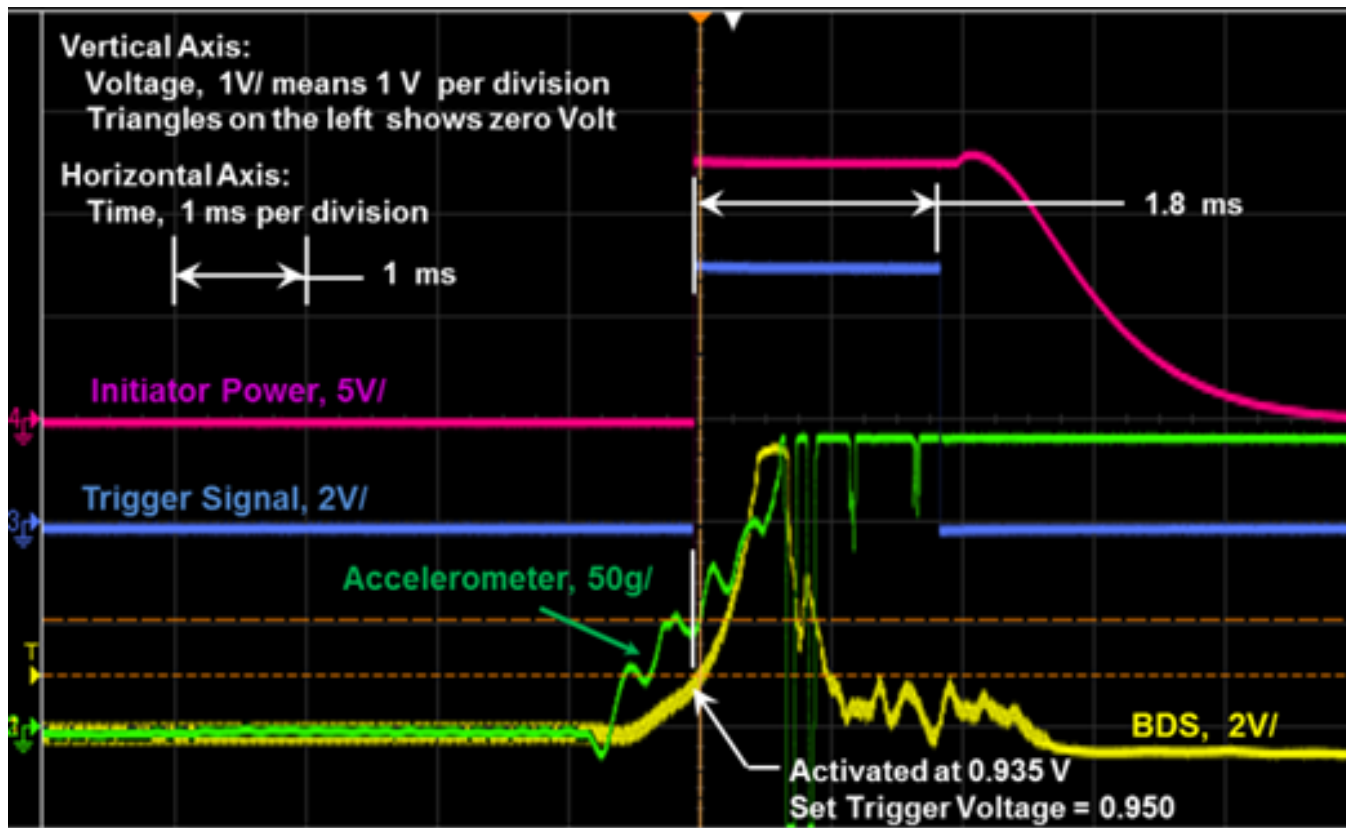
Sampling Rate: 100 MSa/s

# Testing of the Activation System under Accelerations

## Drop Tower Experimental Setup



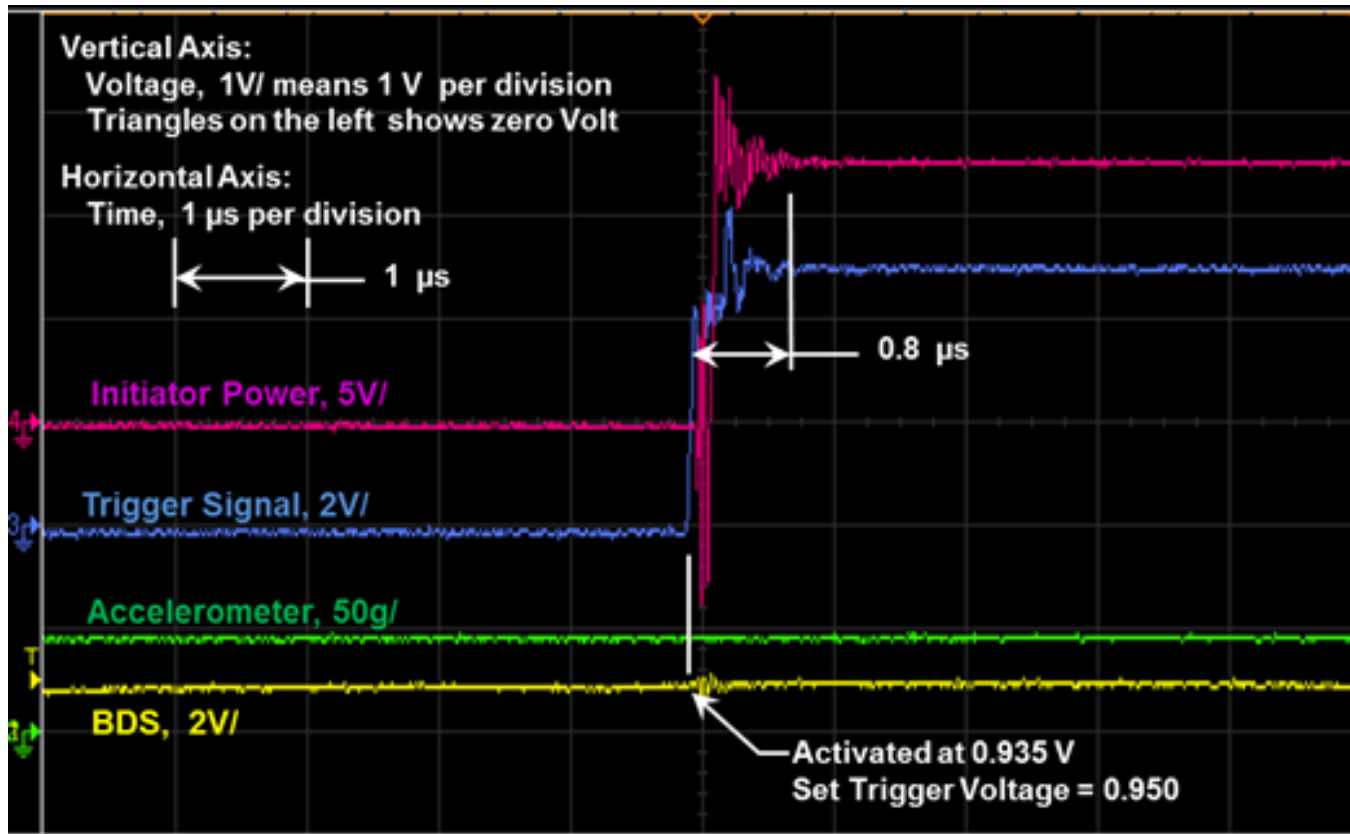
# Testing of the Activation System under Accelerations



Sampling Rate: 100 MSa/s

# Testing of the Activation System under Accelerations

## 1000x Expanded View



Sampling Rate: 100 MSa/s

# Summary and Conclusions I

- **Blast Detection and Seat Safety Activation System was developed and tested.**
- **Primary Components of the System:**
  - **Blast Detection Sensor**
  - **Decision Making Circuitry**
- **Blast Detection Sensor:**
  - **No Power Supply,**
  - **No Signal Conditioning/Amplification**
  - **No Drift or Noise Problems**

# Summary and Conclusions II

- **Deployment System activates Seat Safety System in less than 1  $\mu$ s after it detects the blast event.**
- **Deployment System:**
  - **Self-Contained or Stand-Alone**
  - **Fits in the space under the seat specified in Figure 41 of MIL-STD-1472G**

# Army Path Forward

- **Conduct Drop Tower testing for preliminary system level performance evaluation**
- **Determine threshold levels for Fire / No Fire in the Military vehicle environment (Off Road, Durability and Abuse Related driving environments)**
- **Fine tune Pyrotechnic system activation performance based on trigger time**
- **Complete system design and vehicle level integration**
- **Conduct vehicle level confirmation blast test**

# Acknowledgements

**SBIR funding for this project was provided through the US Army TARDEC under contract W56HZV-13-C-0296. The authors would like to acknowledge great help provided by Virtual EM, Inc. in designing and making components of the electronics module.**

# Contact Information

**Sebastian K. Karwaczynski**

**U.S. ARMY TARDEC**

**BMT-Interior: RDTA-RTI-GSS-INTB**

**6501 E. 11 Mile Rd**

**Warren, MI 48397-5000**

**Ph : (586) 282-0645**

**[Sebastian.K.Karwaczynski.civ@mail.mil](mailto:Sebastian.K.Karwaczynski.civ@mail.mil)**

**Mehmet Uras**

**Paradigm Research and Engineering**

**3077 N. Foxridge Ct.**

**Ann Arbor, Michigan 48105**

**Ph: (734)-730-0080**

**[muras@comcast.net](mailto:muras@comcast.net)**

**Thanks!**